Comparison of field and laboratory weathering rates in carbonate rocks from an Eastern Mediterranean drainage basin: Supplementary material

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Figure S-1: Location map of sampling sites in this study. Sites are marked by blue dots and coordinates are given in Table S-1.

Figure S-2: Schematic diagram of the flow-through experiment. The rock samples were sealed in a Plexiglass flow-through cell. Double-distilled water was injected into the system using a peristaltic pump at a constant rate of 5.4±0.2 ml h^{-1}. During the experiment, the fluid cells were submerged in a temperature controlled circulating bath which maintained temperatures at 25 ±0.01°C. The effluent was collected in bottles and the bottles were replaced every 2-3 days. After each replacement, the effluent in the bottles was sampled and subjected to ICP-MS analysis for major and minor element concentrations.

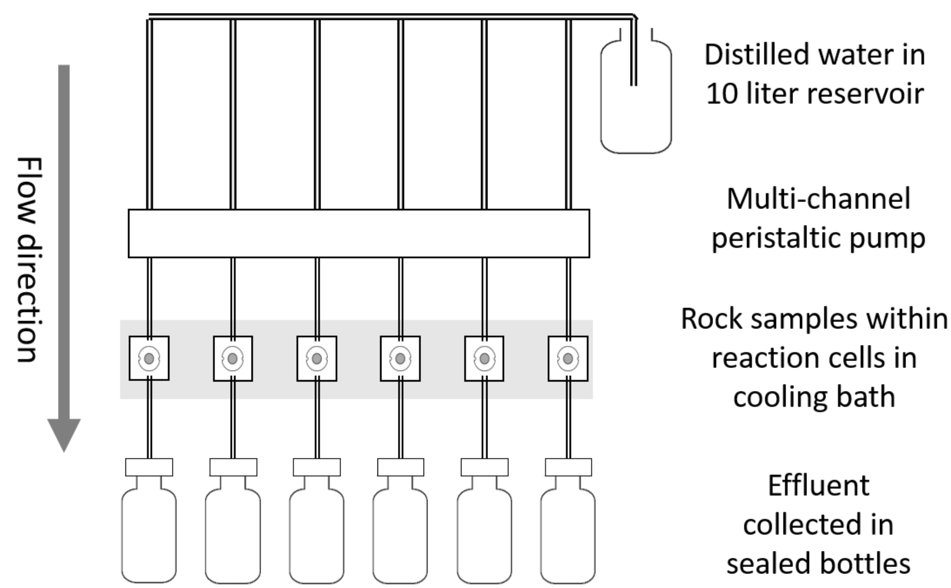

Figure S-3: Denudation rates as a function of present day mean annual precipitation. The solid line represents the linear best fit and the dashed lines represent the upper and lower limit of 95% confidence. The data were compiled from carbonate terrains in Israel, Australia, Japan, China, and France as in Figure 1. Denudation rates calculated from the sites studied by Ryb et al. (2014b, 2014c) were recalculated with the Cronus 2.0 calculator (Marrero et al., 2016a) using the pathway-specific production rates determined by Marrero et al. (2016b) and the Lal/Stone scaling (Table S-3). Other rates appearing in this figure were taken directly from each source (Tables S-4).

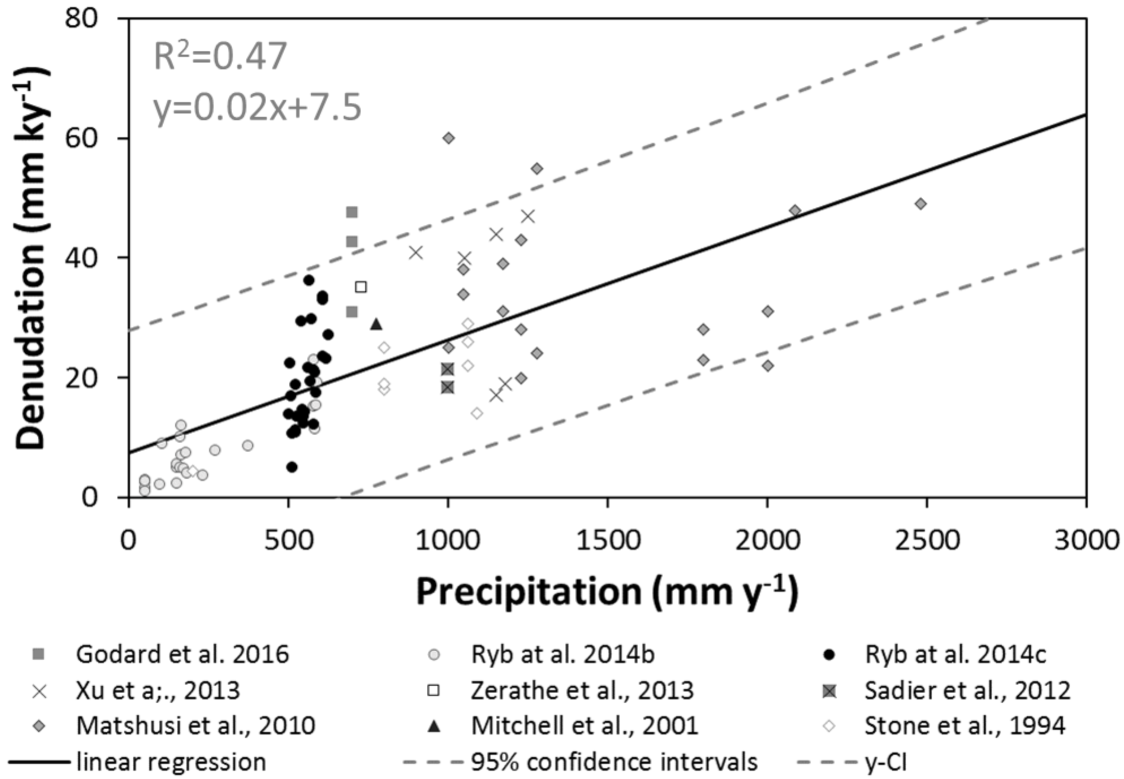

Table S-1: Supplementary data for sample sites and sample properties.

sample	latitude (dd)	longitude (dd)	formation	grain size[a] (μm)	elevation (m)	slope[b] (°)	sample thickness (cm)	shielding[c]	Conc. Cl-36 (Cl-36/g sample)
UB1	31.771	35.197	Weradim	29	765	7	2	1.000	1303439
UB19	31.724	35.023	Weradim	50	515	6	2	1.000	1565513
UB21	31.726	35.051	Aminadav	35	614	5	3	1.000	1268882
UB17	31.724	35.020	Bina	12	451	10	2	1.000	1301517
UB13	31.751	35.042	Aminadav	10	654	5	2	1.000	1510846
UB11	31.767	35.036	Aminadav	15	543	10	5	1.000	1150593
UB9	31.766	35.027	Weradim	10	475	15	2	0.999	1218214
UB7	31.763	35.022	Bina	40	344	20	2	0.999	1097951
UB15	31.725	35.014	Bina	7	361	12	3	1.000	1337401
SQ13	31.736	35.171	Kesalon	34	657	13	5	0.999	2049704

a) Grain size estimation based on environmental scanning electron microscopy (ESEM) imaging.

b) Hillslope gradients values are derived for each sample from a 25 m pixel digital elevation model (DEM; Hall, 1993).

c) The topographic shielding factor, calculated from the angles of the horizon at each bedrock sampling site using a brunton compass.

Table S-2: Long-term cosmogenic ^{36}Cl field denudation rates and laboratory based weathering rates of the same samples.

Sample	field denudation rate[a] (mm ky^{-1})	denudation rate uncertainty (mm ky^{-1})	lab weathering rate[b] (mole cm^{-2} s^{-1})	lab weathering rate[c] (mm ky^{-1})
UB1	17.4	2.7	2.93x10^{-11}	299
UB19	12.4	2	2.74x10^{-11}	283
UB21	12	1.7	3.91X10^{-11}	413
UB17	9.9	1.5	3.17X10^{-11}	339
UB13	11.4	1.7	4.50X10^{-11}	517
UB11	13	1.9	4.86X10^{-11}	558
UB9	12.3	1.8	5.11X10^{-11}	590
UB7	13.1	2	4.85X10^{-11}	565
UB15	10.2	1.6	4.54X10^{-11}	528
SQ13	4.7	0.8	5.01X10^{-11}	584

[a)] Long-term cosmogenic ^{36}Cl field denudation rates, recalculated as described in the methods section.

[b)] Weathering rate based on the laboratory experiments, calculated from the Ca^{2+} and Mg^{2+} concentrations in the effluent (see Eq. 4). The uncertainty of this method associated with the ICP-MS analyses and is estimated to be ±2% (RSD).

[c)] Conversion from mole cm^{-2} s^{-1} to mm ky^{-1} was according to the following equation:
$D = R \cdot (V_{m,calcite} \cdot f_{calcite} + V_{m,dolomite} \cdot f_{dolomite})$ where R is the rate of Ca^{2+} and Mg^{2+} release (see Eq. 4), V_m is the molar volume of calcite and dolomite (correspond to the formulas in Eq. 1 and Eq. 2) and f is the fraction of the mineral in the rock sample.

Table S-3: Published long-term cosmogenic ^{36}Cl field denudation rates compared to the recalculated ^{36}Cl field denudation rates using the Cronus 2.0 calculator.

sample	published denudation rate (mm/ky) Dunai scaling[a]	recalculated denudation rate (mm/ky) LSD scaling[b]	recalculated denudation rate (mm/ky) Lal/Stone scaling[c]
UB1	20.0 ± 2.0	17.4 ± 2.7	18.8 ± 3.0
UB2	30.0 ± 3.0	25.5 ± 3.4	28.3 ± 3.9
UB3	28.0 ± 2.8	27.1 ± 4.7	29.7 ± 5.5
UB4	41.0 ± 4.1	37.9 ± 6.3	42.2 ± 7.5
UB7	20.0 ± 2.0	13.1 ± 2.0	14.6 ± 2.2
UB9	18.0 ± 1.8	12.3 ± 1.8	13.6 ± 2.0
UB11	19.0 ± 1.9	13.0 ± 1.9	14.2 ± 2.1
UB13	15.0 ± 1.5	11.4 ± 1.7	12.4 ± 1.9
UB15	15.0 ± 1.5	10.2 ± 1.6	11.3 ± 1.7
UB17	13.0 ± 1.3	9.9 ± 1.5	10.9 ± 1.6
UB19	14.0 ± 1.4	12.4 ± 2.0	13.5 ± 2.2
UB21	15.0 ± 1.5	12.0 ± 1.7	13.0 ± 1.9
UB23	29.0 ± 2.9	26.9 ± 4.6	29.3 ± 5.2
UB25	17.0 ± 1.7	16.2 ± 2.8	17.5 ± 3.0
SQ3	17.0 ± 1.7	11.0 ± 1.9	12.1 ± 2.1
SQ4	28.0 ± 2.8	18.9 ± 2.6	20.8 ± 2.9
SQ5	22.0 ± 2.2	19.3 ± 3.1	21.2 ± 3.5
SQ6a	22.0 ± 2.2	19.8 ± 3.4	21.6 ± 3.8
SQ7	34.0 ± 3.4	32.6 ± 5.6	36.2 ± 6.6
SQ9	22.0 ± 2.2	17.5 ± 2.6	19.4 ± 2.9
SQ10	15.0 ± 1.5	12.9 ± 1.9	13.8 ± 2.1
SQ11	25.0 ± 2.5	20.4 ± 2.7	22.4 ± 3.1
SQ12	17.0 ± 1.7	15.6 ± 2.5	16.9 ± 2.7
SQ13	6.0 ± 0.6	4.7 ± 0.8	5.1 ± 0.9
SQ14	13.0 ± 1.3	9.9 ± 1.5	10.7 ± 1.6
SQ15	26.0 ± 2.6	24.9 ± 3.9	27.1 ± 4.5
SQ16	24.0 ± 2.4	21.3 ± 3.2	23.2 ± 3.6
SQ17	33.0 ± 3.3	30.3 ± 4.5	33.6 ± 5.3
SQ18	35.0 ± 3.5	29.7 ± 4.0	33.0 ± 4.7
SQ19	28.0 ± 2.8	21.3 ± 2.8	23.6 ± 3.1
AR1	22.6 ± 1.4	21.3 ± 3.4	22.9 ± 3.8
AR2	13.5 ± 0.8	14.2 ± 2.6	15.1 ± 2.8
AR4	11.5 ± 0.7	10.8 ± 1.8	11.4 ± 1.9
AR5	15.1 ± 0.9	14.4 ± 2.4	15.3 ± 2.6
AR6	21.2 ± 1.4	17.8 ± 2.4	19.2 ± 2.6
AR7	10.3 ± 0.3	8.1 ± 1.2	8.6 ± 1.3
AR9	8.6 ± 0.5	7.0 ± 1.1	7.5 ± 1.1
AR11	32.2 ± 2.0	29.9 ± 4.9	33.1 ± 5.7
AR12	8.3 ± 0.5	8.1 ± 1.7	8.7 ± 1.8

AR13	7.1 ± 0.4	6.4 ± 1.1	6.9 ± 1.2
AR14	11.9 ± 0.7	10.8 ± 1.7	11.6 ± 1.8
AR15	12.1 ± 0.8	9.6 ± 1.4	10.3 ± 1.5
AR16	2.3 ± 0.1	2.1 ± 0.5	2.3 ± 0.5
AR18	6.4 ± 0.4	5.2 ± 0.9	5.6 ± 0.9
AR19	9.0 ± 0.6	7.4 ± 1.1	7.8 ± 1.2
AR21	4.0 ± 0.2	3.4 ± 0.6	3.6 ± 0.6
AR23	4.5 ± 0.3	3.8 ± 0.7	4.1 ± 0.7
AR24	5.5 ± 0.3	4.6 ± 0.8	4.9 ± 0.8
AR25	5.6 ± 0.3	4.6 ± 0.8	4.9 ± 0.8
AR26	12.6 ± 0.7	9.3 ± 1.3	10.1 ± 1.4
AR27	8.4 ± 0.5	6.4 ± 1.0	7.0 ± 1.1
AR28	13.6 ± 0.8	11.0 ± 1.6	12.0 ± 1.8
AR30	5.9 ± 0.3	4.6 ± 0.8	5.0 ± 0.8
AR31	2.4 ± 0.1	2.2 ± 0.7	2.6 ± 0.8
AR32	3.3 ± 0.2	2.6 ± 0.5	3.0 ± 0.6
AR33	2.6 ± 0.1	2.3 ± 0.6	2.6 ± 0.6
AR38	1.4 ± 0.1	1.3 ± 0.4	1.6 ± 0.5
AR39	0.9 ± 0.0	0.8 ± 0.3	1.0 ± 0.3
AR40	11.0 ± 0.6	8.1 ± 1.2	9.0 ± 1.3
AR41	2.3 ± 0.1	1.8 ± 0.4	2.1 ± 0.4
AR42	19.1 ± 1.1	13.1 ± 1.8	14.7 ± 2.0
AR43	38.0 ± 2.3	23.3 ± 2.8	26.5 ± 3.3
AR44	22.3 ± 1.3	14.1 ± 1.9	15.8 ± 2.1
AR45	33.3 ± 2.0	25.8 ± 3.7	29.1 ± 4.3

[a)] Long-term cosmogenic 36Cl field denudation rates published in Ryb et al (2014b,c) based on Schimmelpfennig et al., (2009) spreadsheet and (Dunai, 2000) Scaling.

[b)] Recalculated denudation rates using the Cronus 2.0 calculator and production rates determined by Marrero et al. (2016a,b) and the time-dependent Lifton-Sato-Dunai (LSD) scaling scheme. These are the values compared to the laboratory rates in Figure 7 and Table S-2.

[c)] Recalculated denudation rates using the Cronus 2.0 calculator and production rates determined by Marrero et al. (2016a,b) and Lal/Stone scaling (Stone, 2000 after Lal, 1991).

Table S-4: Supplementary data and cosmogenic ^{36}Cl field denudation rate for the studies presented in Figure 1.

Source	location	Altitude (m)	Annual precipitation (mm)	Mean temp. (˚C)	rock	[^{36}Cl] (10^6 at/g)	[Cl] (ppm)	Denudation (mm/ky)	Denudation uncertainty (mm/ky)	production rates calculation	scaling
Godard et al. 2016	Luberon, France	687	750	8	limestone	0.92	4	47.6	4.9	as in Schimmelpfennig et al., 2009	Stone et al., 2000
Godard et al. 2016	Luberon, France	680	750	8	limestone	1.04	4	42.6	4.4	as in Schimmelpfennig et al., 2009	Stone et al., 2000
Godard et al. 2016	Luberon, France	660	750	8	limestone	1.37	2	30.9	3.7	as in Schimmelpfennig et al., 2009	Stone et al., 2000
Xu et al. 2013	Pingba, China	1226	1150	15	limestone	0.793	17.5	44	4.4	---	---
Xu et al. 2013	Longli, China	1110	1050	14	dolomite	2.36	205.6	40	4	---	---
Xu et al. 2013	Hezhang, China	2329	900	12	limestone	2.22	16.2	41	4.1	---	---
Xu et al. 2013	Liupanshui, China	1959	1250	11	limestone	1.77	46	47	4.7	---	---
Xu et al. 2013	Sinan, China	586	1150	17	limestone	1.41	21.7	17	1.7	---	---
Xu et al. 2013	Dejiang, China	577	1180	15	limestone	2.02	94.9	19	1.9	---	---
Zerathe et al., 2013	Southeast France	630	730	---	limestone	0.563	32	35	5	as in Schimmelpfennig et al., 2009	Stone et al., 2000
Sadier et al., 2012	Ardeche, France	245	1000	---	limestone	1.235	10.5	21.5	2.15	as in Schimmelpfennig et al., 2009	Dunne et al., 1999
Sadier et al., 2012	Ardeche, France	245	1000	---	limestone	1.083	11.9	18.5	1.85	as in Schimmelpfennig et al., 2009	Dunne et al., 1999
Matshusi et al., 2010	Naka-tonbetsu, Japan	133	1280	4.9	limestone	0.4	27.97	55	4	as in Stone et al., 1996 and 1998	Stone et al., 2000
Matshusi et al., 2010	Naka-tonbetsu,, Japan	104	1280	4.9	limestone	0.86	28.63	24	2	as in Stone et al., 1996 and 1998	Stone et al., 2000
Matshusi et al., 2010	Shibetsu, Japan	611	1003	5.5	limestone	1.08	10.68	25	1	as in Stone et al., 1996 and 1998	Stone et al., 2000
Matshusi et al., 2010	Shibetsu, Japan	524	1003	5.5	limestone	0.47	7.8	60	4	as in Stone et al., 1996 and 1998	Stone et al., 2000
Matshusi et al., 2010	Iwaizumi, Japan	778	1049	9.9	limestone	0.81	6.47	38	2	as in Stone et al., 1996 and 1998	Stone et al., 2000
Matshusi et al., 2010	Iwaizumi, Japan	490	1049	9.9	limestone	0.76	17.99	34	2	as in Stone et al., 1996 and 1998	Stone et al., 2000
Matshusi et al., 2010	Tono, Japan	594	1171	9.4	limestone	0.85	2.78	31	2	as in Stone et al., 1996 and 1998	Stone et al., 2000
Matshusi et al., 2010	Tono, Japan	614	1171	9.4	limestone	0.71	4.64	39	3	as in Stone et al., 1996 and 1998	Stone et al., 2000
Matshusi et al., 2010	Abukuma, Japan	851	1230	10.4	limestone	1.52	15.79	20	1	as in Stone et al., 1996 and 1998	Stone et al., 2000
Matshusi et al., 2010	Abukuma, Japan	855	1230	10.4	limestone	0.74	10.51	43	3	as in Stone et al., 1996 and 1998	Stone et al., 2000
Matshusi et al., 2010	Abukuma, Japan	834	1230	10.4	limestone	1.11	11.25	28	1	as in Stone et al., 1996 and 1998	Stone et al., 2000
Matshusi et al., 2010	Akiyoshi, Japan	401	2001	13.5	limestone	1.03	26.33	22	2	as in Stone et al., 1996 and 1998	Stone et al., 2000
Matshusi et al., 2010	Akiyoshi, Japan	336	2001	13.5	limestone	0.64	4.27	31	2	as in Stone et al., 1996 and 1998	Stone et al., 2000
Matshusi et al., 2010	Hirao, Japan	432	1800	15.6	limestone	0.75	4.46	28	3	as in Stone et al., 1996 and 1998	Stone et al., 2000
Matshusi et al., 2010	Hirao, Japan	487	1800	15.6	limestone	0.91	4.21	23	1	as in Stone et al., 1996 and 1998	Stone et al., 2000
Matshusi et al., 2010	Hirao, Japan	248	2479	20.6	limestone	0.37	9.85	49	3	as in Stone et al., 1996 and 1998	Stone et al., 2000
Matshusi et al., 2010	Yamazato, Japan	219	2086	22.3	limestone	0.37	10.66	48	4	as in Stone et al., 1996 and 1998	Stone et al., 2000
Mitchell et al., 2001	Galilee, Israel	300	775	20	mixed	0.71	29.6	29	3	as in Stone et al., 1996 and 1998	Dunne et al., 1999
Stone et al., 1994	Victoria, Australia	---	799	---	limestone	1.39	53	18	3	Stone et al., 1994	Stone et al., 1994
Stone et al., 1994	Victoria, Australia	---	799	---	limestone	1.92	126	19	3	Stone et al., 1994	Stone et al., 1994
Stone et al., 1994	Victoria, Australia	---	799	---	limestone	1.35	140	25	4	Stone et al., 1994	Stone et al., 1994
Stone et al., 1994	New South Wales, Australia	---	1062	---	limestone	2.29	38	22	3	Stone et al., 1994	Stone et al., 1994
Stone et al., 1994	New South Wales, Australia	---	1062	---	limestone	1.84	30	26	3	Stone et al., 1994	Stone et al., 1994
Stone et al., 1994	New South Wales, Australia	---	1062	---	limestone	1.69	30	29	3	Stone et al., 1994	Stone et al., 1994
Stone et al., 1994	Northern Territory, Australia	---	1092	---	limestone	2.96	420	14	3	Stone et al., 1994	Stone et al., 1994
Stone et al., 1994	Nullarbor Plain, Australia	---	200	---	limestone	3.74	34	4.5	0.7	Stone et al., 1994	Stone et al., 1994
Stone et al., 1994	Strickland, Papua New Guinea	---	8000	---	limestone	0.36	18	184	22	Stone et al., 1994	Stone et al., 1994

Table S-5: Calcium and magnesium concentrations in the effluent of the long duration flow-through experiments effluent over time

Time from	UB1		UB19		UB21		UB17		UB13	
start (hrs)	**Ca (M)**	**Mg(M)**	**Ca (M)**	**Mg(M)**	**Ca (M)**	**Mg(M)**	**Ca (M)**	**Mg(M)**	**Ca (M)**	**Mg(M)**
1	9.82E-06	2.71E-06	7.84E-06	1.90E-06	1.43E-05	1.13E-06	9.89E-06	2.23E-06	1.61E-05	1.02E-06
2	8.25E-06	2.21E-06	4.75E-06	1.94E-06	9.87E-06	5.51E-07	6.23E-06	1.31E-06	1.25E-05	5.25E-07
3	3.33E-06	1.61E-06	2.63E-06	1.66E-06	8.82E-06	4.41E-07	5.96E-06	1.16E-06	9.69E-06	3.54E-07
27	2.48E-06	1.70E-06	2.09E-06	1.70E-06	7.80E-06	3.37E-07	5.28E-06	8.79E-07	7.91E-06	2.31E-07
50	2.95E-06	1.85E-06	2.36E-06	1.89E-06	7.28E-06	2.29E-07	5.11E-06	9.40E-07	8.39E-06	2.40E-07
96	3.56E-06	2.14E-06	3.03E-06	2.07E-06	6.99E-06	2.85E-07	4.25E-06	1.01E-06	7.42E-06	1.49E-07
146	2.95E-06	2.11E-06	2.59E-06	2.05E-06	6.73E-06	2.63E-07	3.97E-06	1.06E-06	7.36E-06	1.33E-07
192	2.40E-06	2.03E-06	2.51E-06	2.11E-06	6.25E-06	2.69E-07	3.75E-06	1.10E-06	7.33E-06	1.20E-07
266	2.61E-06	2.10E-06	2.48E-06	2.15E-06	5.78E-06	3.23E-07	3.63E-06	1.26E-06	6.94E-06	1.05E-07
359	2.49E-06	2.14E-06	2.33E-06	2.19E-06	5.28E-06	3.75E-07	3.61E-06	1.33E-06	6.66E-06	6.65E-08
433	2.31E-06	2.15E-06	2.29E-06	2.18E-06	4.98E-06	4.09E-07	3.11E-06	1.32E-06	6.34E-06	5.58E-08
504	2.37E-06	2.17E-06	2.30E-06	2.21E-06	4.63E-06	4.66E-07	2.94E-06	1.36E-06	6.21E-06	4.55E-08
600	2.35E-06	2.20E-06	2.28E-06	2.11E-06	4.63E-06	5.08E-07	2.96E-06	1.39E-06	6.24E-06	5.74E-08

Time from start (hrs)	UB11		UB9		UB7		UB15		SQ13	
	Ca (M)	**Mg(M)**	**Ca (M)**	**Mg(M)**	**Ca (M)**	**Mg(M)**	**Ca (M)**	**Mg(M)**	**Ca (M)**	**Mg(M)**
1	1.42E-05	4.39E-07	1.62E-05	6.58E-07	1.62E-05	5.12E-07	1.41E-05	5.12E-07	1.40E-05	3.94E-07
2	1.08E-05	1.64E-07	1.32E-05	4.09E-07	1.06E-05	1.47E-07	1.05E-05	1.47E-07	1.03E-05	1.31E-07
3	9.69E-06	1.30E-07	1.17E-05	3.07E-07	9.24E-06	1.22E-07	1.65E-05	1.22E-07	9.19E-06	8.97E-08
23	7.94E-06	8.68E-08	9.47E-06	2.39E-07	8.09E-06	9.71E-08	8.75E-06	9.71E-08	8.30E-06	1.27E-07
71	7.56E-06	7.28E-08	7.81E-06	1.72E-07	7.09E-06	6.09E-08	8.40E-06	6.09E-08	8.01E-06	8.85E-08
121	7.72E-06	8.56E-08	8.82E-06	2.95E-07	7.55E-06	1.16E-07	8.29E-06	1.16E-07	8.21E-06	9.96E-08
169	7.49E-06	7.90E-08	8.36E-06	2.30E-07	7.21E-06	8.23E-08	8.22E-06	8.23E-08	7.75E-06	6.71E-08
242	7.19E-06	1.00E-07	7.85E-06	2.16E-07	7.02E-06	9.61E-08	7.61E-06	6.86E-08	7.22E-06	8.67E-08
334	8.77E-06	8.65E-08	8.04E-06	1.84E-07	7.64E-06	7.33E-08	7.02E-06	1.52E-08	7.07E-06	2.61E-08
430	7.68E-06	1.02E-07	7.85E-06	1.99E-07	7.68E-06	1.14E-07	7.65E-06	7.94E-08	7.65E-06	8.39E-08
551	7.76E-06	6.34E-08	7.63E-06	1.44E-07	7.00E-06	4.90E-08	7.18E-06	4.36E-08	7.56E-06	5.47E-08
599	7.14E-06	5.47E-08	7.54E-06	1.66E-07	7.09E-06	5.92E-08	6.82E-06	4.94E-08	7.45E-06	3.95E-08

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